THE TROPICAL MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (TMAPS) PROGRAM IN AMERICAN SAMOA: 2015 REPORT

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Robinson S. Mulitalo banding a Many-colored Fruit-Dove at the Mt. Alava TMAPS station

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Cover photograph by Kim Kayano.

EXECUTIVE SUMMARY

Few data exist on the ecology, population status, and conservation needs of landbirds in American Samoa. In an effort to provide baseline population data for these species and to address potential conservation concerns, we initiated a Tropical Monitoring Avian Productivity and Survivorship (TMAPS) program on Tutuila Island in 2012, expanded it to Ta'u Island in 2013, and continued operation on both islands in 2014-2015. Long-term goals of this project are to: (1) provide annual indices of adult population size and post-fledging productivity; (2) provide annual estimates of adult population densities, adult survival rates, proportions of residents, and recruitment into the adult population (from capture-recapture data); (3) relate avian demographic data to weather and habitat; (4) identify proximate and ultimate causes of population change; (5) use monitoring data to inform management; and (6) assess the success of managements actions in an adaptive management framework.

In August 2012 through August 2014 we established and operated eight TMAPS stations in typical habitats utilized by landbirds on Tutuila, American Samoa; two stations needed to be replaced by two others for logistical reasons. Each station consisted of a sampling area of about 20 ha, and within the central 8 ha of this area, 10 12-m long, 30-mm mesh, 4-tier nylon mist nets were erected at fixed net sites and operated for three consecutive days, once per month (a "pulse"), weather permitting. Daily operation of stations followed standardized protocols established by The Institute for Bird Populations for use in the MAPS Program.

During this first 13 months of the program we identified the best seasonal period for a TMAPS program in Samoa as November-March. Therefore, in November 2013, four stations (Malaeloa, Malota, Mount Alava, and Amalau) were re-established on Tutuila, two new stations (Tula and Vatia) were newly established to replace other stations, and we also established six new stations on Ta'u Island, two of which (NPAS - Luamaa and NPAS - Laufuti Stream) on National Park of American Samoa (NPAS) lands. Each of these 12 stations were operated for 1-5 pulses (three consecutive days, once per month) each during both the 2014 (December 2013-March 2014) and 2015 (November 2014-March 2015) seasons.

During the 2015 season, we recorded 81 captures on Tutuila, 319 captures on Ta'u, and 400 captures overall, of 10 bird species: Wattled Honeyeater (220 captures), Samoan Starling (92), Collared Kingfisher (38), Samoan Shrikebill (23), Polynesian Starling (11), Blue-crowned Lory (5), Purple-capped Fruit-Dove (4), White-rumped Swiftlet (4), Buff-banded Rail (2), and Many-colored Fruit-Dove (1). The Many-colored Fruit-Dove was the first capture of this species for the program. The population size at the Ta'u stations, measured by adults captured per 600 net-hrs, was nearly twice that of the Tutuila stations, when 2015 data from all six stations and all species were pooled, but reproductive index, measured as young captured per adults captured, was similar on each island.

On Tutuila, both population sizes and reproductive success increased slightly between 2014 and 2015, the increase in population size driven primarily by a large increase in captures of adult Wattled Honeyeaters, whereas reproductive index increased for all species except Wattled Honeyeater. On Ta'u, population sizes decreased rather dramatically from 2014 to 2015, a decrease that occurred in all of the six most commonly caught native landbirds, whereas

reproductive index showed a dramatic increase between 2014 and 2015. This sort of pattern, both among and within species on each island, may indicate a density-dependent effect on reproductive success and, subsequently, population size. Higher reproductive success one year might lead to higher population size but lower success the next year, due to an increased number of inexperienced younger birds in a denser adult population. Lower reproductive success that year might then lead to lower populations the following year but higher success due to more-experienced birds in a lower-density population. It will be interesting to see if this pattern continues in future years.

The overall population size at the Ta'u stations, during both 2014 and 2015 combined was nearly three times that of the Tutuila stations whereas reproductive success was higher on Tutuila than on Ta'u. Higher adult population sizes on Ta'u than on Tutuila appears to reflect better habitat quality at our Ta'u stations than at the Tutuila stations. The disparity in reproductive index is more difficult to explain but might relate to an overall density-dependent effect, as mentioned above.

Using three seasons of data from the four stations operated on Tutuila during all three years, estimates of annual adult survival rates were 0.754 for Collared Kingfisher and 0.828 for Wattled Honeyeater. These are generally very high rates; by comparison, survivorship estimates among MAPS stations in North America vary between 0.4 and 0.6 for most species. With four years of data, precision in these estimates will increase greatly, we should be able to estimate survivorship for additional species, and we will be able to use a model allowing us to account for transient individuals in the population.

Extensive data on molt, plumage, breeding condition, skull pneumaticization, and morphometrics have been coupled with preliminary data from museum specimens to provide a comprehensive manual on molt, age and sex determination criteria for the resident birds of American Samoa. The information compiled for this manual has been accepted for publication in the scientific literature and we also plan to publish the full-scale manual for permanent use in the field.

Continuation of the current sampling protocol will yield critical data on survival, recruitment, and population growth rates for up to seven target native landbird species on Tutuila and Ta'u. Furthermore, in part to assess population dynamics and the natural history of the endangered Shy Ground-Dove, we plan to establish six TMAPS stations on Ofu and Olosega during the 2016 season. Additional seasons worth of data will allow us to better understand year-to-year dynamics, including trends in population sizes, and will enable us to estimate survival rates for up to seven target species on each island. We can then assess how much reproductive success and survivorship are driving population size dynamics, we can use our habitat data to assess how habitat quality affects each of these parameters, and we will be able to make recommendations for habitat and land management for conservation purposes. The need for such conservation approaches is pressing given the many potential threats to the persistence of Pacific insular populations such as habitat loss, avian disease, and exotic predators. We look forward to continuing this important work in the coming years.

INTRODUCTION

Birds are sensitive indicators of environmental quality and ecosystem health (Morrison 1986, Hutto 1998), and they are the focus of many regional and continental scale monitoring efforts (Gregory et al. 2005, Sauer et al. 2008). Most broad-scale bird monitoring has involved counts of birds to index abundance and estimate trends (Bart 2005), but monitoring of demographic rates (including productivity, recruitment, and survival) is needed to infer actual causes of population changes (DeSante et al. 2005). Because demographic rates are directly affected by environmental stressors or management actions, they can more-accurately reflect short-term and local environmental changes (Temple and Wiens 1989, DeSante and George 1994). Demographic data can also be used to identify stages of the life cycle that are most important for limiting bird populations (DeSante et al. 2001, 2014, 2015; Holmes 2007; Saracco et al. 2008, 2009) and can be modeled as functions of predictive population analyses to assess the viability of populations (Noon and Sauer 1992; Saracco et al. 2010a, 2010b).

Application of standardized, constant-effort mist netting and modern capture-recapture analytical techniques is an effective means of monitoring demographic rates of many landbird species (DeSante et al. 2005, 2015). In 1989, a long-term landbird mark-recapture effort was initiated in North America by The Institute for Bird Populations (IBP), with the establishment of the Monitoring Avian Productivity and Survivorship (MAPS) program in (DeSante 1992). The MAPS program is a cooperative network consisting of hundreds of constant-effort mist-netting stations operated across North America each summer (over 1,200 stations overall) that has provided demographic data for over 180 landbird species (DeSante and Kaschube 2007, Saracco et al. 2010b, DeSante et al. 2015). Similar programs exist in Europe, where they are central components of national and international bird-monitoring efforts (e.g., Peach et al. 2004). The MAPS program has been utilized to monitor bird demography by many U.S. federal agencies, including the National Park Service, Department of Defense, USDA Forest Service, and USDI Fish and Wildlife Service.

IBP has also established a "Tropical MAPS" (TMAPS) program to collect similar data on avian vital rates in tropical areas, where breeding may occur year-round. The first TMAPS project was established on Saipan, Commonwealth of the Northern Marianas Islands, in 2008 and has provided important new information on population abundance and trends, breeding and molting seasonality, vital rates, age-determination criteria, morphology, and ecology of the resident landbirds on this island (Radley et al. 2011, Junda et al. 2012, Saracco et al. 2015).

In August 2012, IBP, in collaboration with the Department of Marine and Wildlife Resources (DMWR) in American Samoa, established a five-year TMAPS program on the island of Tutuila. This effort aims to provide baseline data on landbird populations of American Samoa and a foundation for informing conservation strategies for its indigenous insular avifauna. Long-term goals are to: (1) provide annual indices of adult population size and post-fledging productivity (from constant-effort capture data); (2) provide annual estimates and trends of adult population size, adult survival rates, proportions of residents, and recruitment into the adult population (from capture-recapture data); (3) relate avian demographic data to seasonal weather patterns and habitat; (4) identify proximate and ultimate causes of population change; (5) use monitoring data to inform management; and (6) assess the success of any management actions in an adaptive management framework. In order to estimate productivity and recruitment, accurate criteria for determination of each captured bird's age is needed, which in turn relies on knowledge of molting seasons and strategies. Molting patterns and age-determination criteria for Samoan landbirds were examined, based on museum specimens and captures during 2012-2014, and are detailed by Pyle (2014a) and Pyle et al. (in press).

The initial establishment of TMAPS stations and summary of capture data from 16 TMAPS stations on Tutuila and on Ta'u operated during August 2012 though March 2014 were described by Pyle et al. (2012, 2013, 2014a). Twelve of these 16 stations, six on Tutuila and six on Ta'u, were operated during December 2013-March 2014 (the "2014 season") and again during November 2014-March 2015 (the "2015 season"). Here we provide a comprehensive summary of captures, indices of population size (capture rates), and productivity for these 12 stations operated on Tutuila and Ta'u during the 2015 season. We also compare capture and vital rates between the two islands and from year to year on each island, and we provide a preliminary analysis of survivorship for two species on Tutuila, as based on mark-recapture analysis on three seasons of data (2013-2015).

STUDY AREAS AND METHODS

In July-August 2012 we established six TMAPS stations in typical habitats utilized by landbirds on Tutuila, American Samoa, to be operated for 13 consecutive months (Pyle et al. 2012, 2013). During this period two stations (Fagatele Bay and Olovalu Crater) were discontinued due to access problems and low capture rates, and two new stations were established in their stead. The six remaining stations were operated for most of the period, including the 2013 season (December 2012-March 2013). In November 2013, four of these six stations (Malaeola, Malota, Mount Alava, and Amalau) were re-established on Tutuila and two additional stations (Tula and Vatia) were newly established to replace other stations (Aoloau and Loto'asi) which could not continue during the 2014 season due to development and/or access problems (Pyle et al. 2014a). These final six stations (Malaeloa, Malota, Mount Alava, Amalau, Tula, and Vatia) were then operated during both the 2014 and 2015 seasons. Locations of all 10 stations on Tutuila are shown in Figure 1, and descriptions and a summary of effort for each of the active six stations during the 2015 season are given in Table 1. On Ta'u, six stations (NPAS- Luamaa, NPAS - Laufuti Stream, Fala'a, Usu Nua, Saunoa, and Aokuso) were established in November 2013 and each station was operated during both the 2014 (Pyle et al. 2014a) and 2015 seasons. The locations of these six stations are shown in Figure 2, and descriptions and a summary of effort for each station during the 2015 season are given in Table 2. The two stations marked "NPAS" on the map are located in the National Park of American Samoa.

Each of the 12 stations was operated for three consecutive days, once per month (a "pulse"), weather permitting. Each station consisted of a sampling area of about 20 ha, and within the central 8 ha of this area, 10 12-m long, 30-mm mesh, 4-tier nylon mist nets were erected at fixed net sites (DeSante et al. 2014). Daily operation of stations followed standardized protocols established by The Institute for Bird Populations for use in the MAPS Program (DeSante et al. 2014). Mist-netting effort data (i.e., the number and timing of net-hours on each day of operation) were collected in a standardized manner by recording net-opening, net-checking, and net-closing times to the nearest 10 minutes. We aimed to operate nets for six morning hours per day, beginning at local sunrise. Inclement weather (especially heavy rain) sometimes truncated operation on a particular day, resulting in variable overall effort among stations (Tables 1 and 2). Station operation was carried out by IBP and DWMR biologists and assistants. In 2015 these included Kayano, Reese, Morgan, Mulitalo, Tigilau, and Tuvalu (see also Acknowledgements). All banders were trained in TMAPS protocols by IBP staff biologist Taylor, supervised locally by Kayano and Reese, and supervised remotely by Helton and Pyle.

With few exceptions, all birds captured were identified to species, age, and sex based on criteria outlined by Pyle (2014a) and Pyle et al. (in press). Unbanded birds were banded with USGS/BRD numbered aluminum leg bands and recaptured birds (those that had been banded previously) were fully processed. Birds were released immediately upon capture and before being banded or processed if situations arose where bird safety would be compromised. The following data were taken on all birds captured, including recaptures, according to MAPS guidelines (DeSante et al. 2014):

- capture code (newly banded, recaptured, band changed, unbanded)
- band number
- species
- age, how aged, and molt-plumage code (see below)
- sex (if possible to determine) and how sexed (if applicable)
- extent of skull pneumaticization
- breeding condition of adults (i.e., extent of cloacal protuberance or brood patch)
- extent of juvenal plumage in young birds
- extent of body and flight-feather molt
- extent of primary-feather wear
- presence of molt limits and plumage characteristics
- wing chord
- fat class and body mass
- date and time of capture (net-run time)
- station and net site where captured
- any pertinent notes.

Detailed molt data and images were obtained for most captures, to continue documenting molt strategies and ageing and sexing criteria for American Samoan landbirds (Pyle 2014a, Pyle et al. in press). These data and images were examined by Pyle to assess accuracy of age determinations and to maintain seasonal criteria for acceptable age coding. Because breeding can occur year-round in American Samoa and the peak breeding season spans the end of the calendar year (December/January), the calendar-year-based ageing system used for MAPS (DeSante et al. 2014) could not be used for this program. Instead, we aged birds according to the molt-plumage (WRP) system following Wolfe et al. (2010) and Johnson et al. (2011); see also Pyle et al. (2015) for details. Our system was modified to reflect the molt and plumage strategies found for our captured species in American Samoa (Pyle 2014a, 2014b). In addition, first-cycle birds were scored as either greater than or less than six months of age, based on skull and feather wear data. A final determination of age for productivity analyses, young or adult, was determined through a combination of the WRP designation and whether or not young birds were at least six months of age (Pyle 2014b).

Breeding status of each species seen, heard, or captured at each TMAPS station on each day of operation was recorded, using techniques similar to those employed for breeding bird atlas projects, as confirmed breeder, likely breeder, or non-breeder (DeSante et al. 2014). Habitat data were collected for each station following Nott et al. (2003), and using the vegetation classification system of Viereck et al. (1992). John W. Shipman of Zoological Data Processing, Socorro, NM, entered all banding data. We verified banding data by running all records through a series of specialized computer programs to (1) check the validity of all codes entered and the ranges of all numerical data, (2) compare station, date, and net fields from the banding data with those from the effort and breeding status data, (3) cross-check species, age, and sex determinations against data such as skull pneumatization and breeding characters indicative of age and sex, and (4) detect unusual or duplicate band numbers, unusual band sizes, or recaptures indicating inconsistent species, age, or sex determinations. Discrepancies or suspicious data identified by these programs were corrected by hand, if necessary. We used wing chord, body mass, fat content, date and station of capture, and pertinent plumage criteria as supplementary information for the correct determination of species, age, and sex (Pyle 2014a, Pyle et al. in press). As mentioned above, photographs of most captures were examined to provide additional verification of age and sex determinations.

For each species and for all species pooled, we calculated (1) numbers of newly banded birds, recaptured birds, and birds released unbanded; (2) numbers and capture rates of individual birds at each station (birds per 600 net-hours, a standard unit for between-station or regional comparisons; DeSante et al. 2014); and (3) the ratio of young to adult birds representing a reproductive index (Peach et al. 1996). We used these standardized indices to make comparisons of bird dynamics between stations and between the two islands. We conducted modified Cormack-Jolly-Seber mark-recapture analyses (Pollock e al. 1990, Lebreton et al. 1992) using the computer program TMSURVIV on three seasons of banding data from Tutuila, for two species in which, on average, at least 2.5 adults per year were captured, at least two between-season recaptures were recorded, and calculated recapture probabilities were realistic (neither 0.0 or 1.0), at the four stations operated during all three seasons. For each of the target species, we calculated maximum-likelihood estimates and standard errors (*SE*) of adult survival probability (φ) and adult recapture probability (p) obtained by the use of a non-transient model. Recapture probability is defined as the conditional probability of recapturing a bird in a subsequent year that was banded in a previous year, given that it survived and remained at the station.

RESULTS

A summary of captures of each species during the four TMAPS pulses during the 2015 season (November 2014 through March 2015) is provided for all 6 stations of each island combined (Table 3) and for each station separately on Tutuila (Table 4) and Ta'u (Table 5). Overall, we banded 52 birds on Tutuila and 229 birds on Ta'u, we recaptured 26 birds on Tutuila and 74 birds on Ta'u, and 3 birds on Tutuila and 16 birds on Ta'u were released unbanded; thus, we recorded a total of 81 captures on Tutuila, 319 captures on Ta'u, and 400 captures overall (Table 3). Ten species were captured during the 2015 season (see Table 3 for scientific names), 8 on Tutuila, 9 on Ta'u, and six on both islands, including the first capture of the Many-colored Fruit-Dove for the program (on Tutuila).

The most commonly captured species on both islands combined were Wattled Honeyeater (220 captures), followed by Samoan Starling (92), Collared Kingfisher (38), Samoan Shrikebill (23), Polynesian Starling (11), Blue-crowned Lory (5), Purple-capped Fruit-Dove (4), White-rumped Swiftlet (4), Buff-banded Rail (2), and Many-colored Fruit-Dove (1). Species captured in previous years but not during the 2015 season have included White-tailed Tropicbird (*Phaethon lepturus*), White Tern (*Gygis alba*), Purple Swamphen (*Porphyrio porphyrio*), Pacific Pigeon (*Ducula pacifica*), Long-tailed Cuckoo (*Eudynamys taitensis)*, Red-vented Bulbul (*Pycnonotus cafer*), Common Myna (*Acridotheres tristis*), Jungle Myna (*Acridotheres fuscus*), and Cardinal Honeyeater (*Myzomela cardinalis*). Cardinal Honeyeater and the two myna species had higher capture rates at some of the discontinued stations on Tutuila. One other native landbird species found on these islands, the Shy Ground-Dove (*Gallicolumba stairi*), occurs only on Ofu Island and has not yet been captured at TMAPS stations.

On Tutuila (Table 4), when all species were pooled, the highest numbers of captures were recorded at the Mount Alava station (33), followed by Malota (28), Vatia (12), Malaeloa (4), and Amalau and Tula (2 each). Species richness was highest at Amount Alava (7 species), followed by Malota (4), Vatia (3), Malaeloa and Amalau (2 each), and Tula (1). On Ta'u (Table 5), the highest numbers of captures were recorded at Usu Nua (81), followed by Aukosu (77), NPAS - Luamaa (60), Saunoa (39), Fala'a (32), and NPAS - Laufuti Stream (30), and species richness was highest at Usu Nua and Saunoa (7 species each), followed by NPAS - Laufuti Stream, Fala'a and Aokuso (4 each), and NPAS - Luamaa (3).

Because of variation in the number of net-hours (Tables 1 and 2), it is best to compare overall population densities in terms of individual adults captured per 600 net-hours (Tables 3, 6 and 7). Among stations on each island, adult capture rates followed somewhat similar orders to those for number of captures. On Tutuila (Table 6), when all species were pooled, adult capture rates were highest at Mount Alava (26.9 adults per 600 net-hours), followed by Malota (24.9), Vatia (13.9), Malaeloa (13.0), Amalau (7.5) and Tula (5.5). Captures of young showed greater variation between stations, being highest at Malota (17.8 young per 600 net-hours), followed by Vatia (9.3), and Mount Alava (3.7), with Malaeloa, Amalau, and Tula capturing no young birds (0.0 each). Reproductive index showed the same order as young captured, being highest at Malota (0.71 young/adult each), followed by Vatia (0.67), Mount Alava (0.14) and Malaeloa, Amalau, and Tula (0.00).

On Ta'u (Table 7), adult capture rates were highest at Aukuso (48.4 adults per 600 net-hours), followed by Usu Nua (46.9), NPAS - Laufuti Stream (39.8), Fala'a (33.3), NPAS - Luamaa (30.4), and Saunoa (24.4). Capture rates of young again followed a different order than those of adults, being highest at Usa Nua (18.8 young per 600 net-hours), followed by Aukuso (16.1), NPAS - Luamaa (13.2), Fala'a (11.7), Saunoa (8.9), and NPAS - Laufuti Stream (5.2). As such, reproductive index again showed a completely different order, being highest at NPAS- Luamaa (0.43 young per adult), followed by Usu Nua (0.40), Saunoa (0.36), Fala'a (0.35), Aokuso (0.33), and NPAS - Laufuti (0.13).

The overall population size at the Ta'u stations during the 2015 season (37.4 adults per 600 net-hours) was nearly twice those of the Tutuila stations (19.1 adults per 600 net-hours), when data from all six stations and all species were pooled, capture rates of young birds overall were also higher on Ta'u (12.9 young per 600 net-hours) than on Tutuila (6.6 young per 600 net-hours) and reproductive index was similar on each island (0.35 young/adult).

On Tutuila, adult population sizes and reproductive success were higher during the 2013 season than during either of the 2014 or 2015 seasons (Table 8); however, these values are based on only four stations (excluding Vatia and Tula which had lower capture rates) and are thus not directly comparable to those based on six stations from 2014 or 2015; 2013 data are presented for information only. For all species pooled, both population sizes and reproductive success increased slightly between 2014 and 2015 on Tutuila. This increase was driven by a large increase in Wattled Honeayter capture rates, from 8.60 to 13.25 adults per 600 net-hrs; four other native landbirds with more than one capture, Purple-collared Fruit-Dove, Collared Kingfisher, Samoan Starling, and Polynesian Starling, all decreased in capture rate between the two years. Interestingly, reproductive index showed the opposite pattern, increasing between 2014 and 2015 for these four species but decreasing for Wattled Honeyeater.

On Ta'u, population sizes decreased rather dramatically from 2014 to 2015, from 62.70 to 37.35 adults per 600 net-hrs, when all species were pooled (Table 8). This decrease seemed species-wide, occurring in all of the six most commonly caught native landbirds, Purple-capped Fruit-Dove, Blue-crowned Lory, Collared Kingfisher, Samoan Shrikebill, Wattled Honeayeater, and Samoan Starling. Only for the less-commonly captured Polynesian Starling did adult population size increase in 2015. Reproductive index, on the other hand, showed a dramatic increase between 2014 and 2015, from 0.14 to 0.34 young/adults when all species were combined. This increase was driven by large increases in the two most commonly captured species, Wattled Honeyeater and Samoan Starling; for the other five native landbirds reproductive index was similar or decreased slightly between 2014 and 2015.

Given variation in between-year changes on each island, it is best to use the 2014-2015 mean values for comparisons between the two islands (Table 8). The overall population size at the Ta'u stations (mean 50.03 adults per 600 net-hours for these two seasons) was nearly three times that of the Tutuila stations (17.48 adults per 600 net-hours) when data from all 12 stations and all species were pooled. Reproductive success, on the other hand, was higher on Tutuila (0.31 young/adult) than on Ta'u (0.25 young/adult) when all species were pooled.

Among landbird species captured on both islands, Collared Kingfisher, Wattled Honeyeater, and Samoan Starling had higher capture rates on Ta'u than on Tutuila whereas Purple-capped Fruit-Dove, Many-colored Fruit-Dove, and Polynesian Starling had higher capture rates on Tutuila. Higher adult population sizes on Ta'u than on Tutuila for Collared Kingfisher, Wattled Honeyeater, and Samoan Starling, the three most commonly captured species, explains the large overall difference in capture rates between the two islands. Reproductive index was higher on Tutuila for Purple-capped Fruit-Dove collared Kingfisher, Wattled Honeyeater, and Samoan Starling and it was lower on Tutuila than on Ta'u for Polynesian Starling.

Using three seasons of data (2013-2015) from the four stations operated on Tutuila during all three years (Malaeola, Malota, Mount Alava, and Amalau), estimates of annual adult survival rate (φ) and recapture probability (p) could be obtained for two species, Collared Kingfisher and Wattled Honeyeater (Table 9). Three other species, Purple-capped Fruit-Dove, Samoan Starling, and Polynesian Starling, had sufficient capture and recapture data but the analysis produced survivorship or recapture values of either 0.0 or 1.0, which are unrealistic and indicate that more data would be needed to produce valid estimates. Survivorship estimates, using the non-transient models, were 0.754 for Collared Kingfisher and 0.828 for Wattled Honeyeater, while recapture probabilities were 0.236 for Collared Kingfisher and 0.108 for Wattled Honeyeater. The standard errors (*SE*s) for these four values were high, resulting in high coefficients of variance (CVs), and generally indicating low precision to these survival estimates.

DISCUSSION

During the first 13 months of the Tropical Monitoring Avian Productivity and Survivorship (TMAPS) program in American Samoa, from August 2012 to August 2013, we established seasonality for resident breeding birds on Tutuila, and that the best five-month period for the program, based on peak breeding for most native species, would be November-March. During November 2013, we therefore re-established four stations on Tutuila, established two new stations on Tutuila and six new stations on Ta'u Island, and operated these 12 stations for 1-5 pulses each during the 2014 (December 2013-March 2014) and 2015 (November- 2014-March 2015) seasons.

During the 2015 season, we recorded 81 captures on Tutuila, 319 captures on Ta'u, and 400 captures overall, of 10 bird species. The most commonly captured species, on both islands combined, were Wattled Honeyeater, Samoan Starling, Collared Kingfisher, Samoan Shrikebill, Polynesian Starling, Blue-crowned Lory, Purple-capped Fruit-Dove, and White-rumped Swiftlet. These are all native indigenous species. The remaining two species were captured just once each, but included the first capture of a Many-colored Fruit-Dove for the program. In 2015, population size at the Ta'u stations was nearly twice that of the Tutuila stations, when data from all six stations and all species were pooled, but reproductive index was similar on each island.

On Tutuila, for all species pooled, both population sizes and reproductive success increased slightly between 2014 and 2015, the increase in population size driven primarily by a large increase in Wattled Honeayter. Reproductive index, on the other hand, increased for all species except Wattled Honeyeater. On Ta'u, population sizes decreased rather dramatically from 2014 to 2015 when all species were pooled, a decrease that appeared to be species-wide, occurring in all of the six most commonly caught native landbirds. Reproductive index, on the other hand, showed a dramatic increase between 2014 and 2015, driven by large increases in the two most commonly captured species, Wattled Honeyeater and Samoan Starling. This sort of pattern, both among and within species on each island, may indicate a density-dependent effect on reproductive success and, subsequently, population size. Higher reproductive success one year (e,g, 2014 for Wattled Honeyeater on Tutuila) might lead to higher population size but lower success the next year, due to an increased number of younger birds in the population that are not as successful, due both to inexperience and a denser breeding population. Lower reproductive success one year (e.g., most species on Ta'u in 2014) might lead to lower populations the following year but higher success due to more-experienced birds in a lower-density population. It will be interesting to see if these patterns continue on each island during the 2016 season and beyond.

The overall population size at the Ta'u stations over both years combined (mean 50.03 adults per 600 net-hours) was nearly three times that of the Tutuila stations (17.73 adults per 600 net-hours). Reproductive success, on the other hand, was higher on Tutuila (0.31 young/adult) than on Ta'u (0.24 young/adult) when all species were pooled. Higher adult population sizes on Ta'u than on Tutuila for Collared Kingfisher, Wattled Honeyeater, and Samoan Starling, the three most commonly captured species, explains the large overall difference in capture rates between the two islands, and appears to reflect better habitat quality at our Ta'u stations than at the Tutuila stations. The disparity in reproductive index, however, is more difficult to explain. It may relate to an overall density-dependent effect, as mentioned above. The higher apparent population densities on Ta'u may result in lower overall success. In this case, survivorship may also be higher on Ta'u than on Tutuila, something we will be able to assess following the 2016 season.

Using three seasons of data from the four stations operated on Tutuila during all three years, estimates of annual adult survival rates were 0.754 for Collared Kingfisher and 0.828 for Wattled Honeyeater. These are generally very high rates; by comparison, survivorship estimates among MAPS stations in North America vary between 0.4 and 0.6 for most species (DeSante et al. 2015). However, standard errors and coefficients of variance for these estimates were high, generally indicating low precision. Low precision is expected based on a minimum of three years of data for which mark-recapture models can be run; however, with four years of data precision will increase greatly and there is a good chance that we will also be able to estimate survival in Purple-capped Fruit-Dove and the two starling species on Tutuila. Once four years of data become available, furthermore, we will be able to use a transient model (Pradel et al. 1997, Nott and DeSante 2002) to provide survival estimates that are less biased with respect to transient individuals and to estimate the proportion of residents among newly captured adults. Finally, we will also be able to provide three-year survival estimates for up to five species on Ta'u, where more captures and recaptures are being recorded.

Extensive data on molt, plumage, breeding condition, skull pneumaticization, and morphometrics were collected on eight of the 12 species, and have been coupled with preliminary data from museum specimens to provide a comprehensive manual on molt, age and sex determination criteria for the resident birds of American Samoa (Pyle 2014a). The information compiled for this manual has been accepted for publication in the scientific literature (Pyle et al., in press) and a full-scale manual for permanent use in the field is planned for the coming year.

Continuation of the current sampling protocol will yield critical data on the survival, recruitment, and population growth rates for up to seven target native landbird species on Tutuila and Ta'u. Furthermore, in part to assess population dynamics and the natural history of the endangered Shy Ground-Dove, we plan to establish six TMAPS stations on Ofu and Olosega during the 2016 season. Our goal is to continue to operate six stations on each of the three island groups during November-March of each season through at least 2017. Five seasons worth of data will allow us to better understand year-to-year dynamics, including trends in population sizes, and will enable us to estimate survival rates for up to seven target species on each island. We can then assess how much reproductive success and survivorship are driving population size dynamics, we can use our habitat data to assess how habitat quality affects each of these parameters, reproductive success in particular, and we will be able to make land-management recommendations for habitat conservation or restoration. The need for such approaches is pressing given the many potential threats to the persistence of Pacific insular populations such as habitat loss, avian disease, and exotic predators such as brown treesnake (*Boiga irregularis*), which has reduced or eliminated many landbirds on Guam in the Marianas Islands (Frits and Rhodda 1998). We look forward to continuing this important work in the coming years.

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Table 1. Summary of the TMAPS program on the island of Tutuila, American Samoa (AMSA) during the 2015 season, November 2014 through March 2015.

Station					November 2014 ï March 2015 operation		
Name	Code	Major Habitat Type	Latitude-longitude	Avg Elev. (m)	Total number of net-hours	No. of pulses	Inclusive dates
Malaeloa	MALA	Old-growth moderate-slope, lowland tropical evergreen forest; ephemeral wetlands	14°19'50"S, 170°46'26"W	43	184.17	2	12/18/14 ï 01/15/15
Malota	MALO	Ridge-spine, natural tropical forest	14°18'17"S, 170°49'11"W	144	337.17	4	12/24/14 ï 03/20/15
Mount Alava	MTAL	Old-growth steep-slope, tropical forest; some secondary forest and plantation	14°17'05"S, 170°42'46"W	215	490.00	5	11/06/14 ï 03/14/15
Amalau	AMAL	Mixed, old-growth and secondary lowland tropical forest; some plantation	14°15'19"S, 170°39'32"W	35	160.33	2	12/29/14 - 3/25/15
Tula	TULA	Primary forest on steep ridge with mature *Callophylum* and *Dysoxylum* trees.	14°14'58"S, 170°34'35"W	380	110.00	1	01/02/15 ï 01/05/15
Vatia	VATI	Mixed, old-growth and secondary lowland tropical forest on a hillside with banana and coconut plantation at base.	14°14'41"S, 170°40'35"W	135	258.50	3	11/15/14 ï 01/14/15
ALL STATIONS					1540.17	5	11/27/13 ï 03/26/14

Table 2. Summary of the TMAPS program on the island of Tau, American Samoa (AMSA) during the 2015 season, November 2014 through March 2015.

Station						November 2014 ï March 2015 operation		
Name	Code	Major Habitat Type	Latitude-longitude	Avg Elev. (m)	Total number of net-hours	No. of pulses	Inclusive dates	
NPAS-Luamaa	LUAM	Coral rubble lowland littoral forest	14°15'24"S, 169°25'28"W	8	591.33	4	12/08/14 ï 02/25/15	
NPAS - Laufuti Stream	LAUF	Gentle-slope mature lowland secondary forest	14°14'54"S, 169°26'31"W	835	346.83	3	12/17/14 ï 02/23/15	
Falaôa	FALA	Gentle-slope mature lowland secondary forest	14°14'49"S, 169°29'59"W	424	360.33	3	12/02/14 ï 02/05/15	
Usu Nua	USUN	Agriculturally managed secondary forest	14°13'59"S, 169°30'39"W	210	575.83	5	11/27/14 ï 03/04/15	
Saunoa	SNOA	Agriculturally managed land with some moderate-slope secondary forest alongside clearcut plantation	14°13'11"S, 169°30'14"W	435	540.17	4	11/29/14 ï 02/11/15	
Aokuso	AOKU	Agriculturally managed secondary forest bordering herbaceous sand strand	14°12'49"S, 169°27'13"W	43	557.33	4	12/12/14 ï 03/02/14	
ALL STATIONS					2971.83	5	11/27/14 ï 03/04/15	

Table 3. Summary of combined results for all 12 American Samoan TMAPS stations operated during the 2015 season, November 2014 through March 2015.

	Island of Tutuila						Island of Tau					
	Birds captured			Birds/600 net-hours			Birds captured			Birds/600 net-hours		
Species (Common and Scientific Names)	Newly banded	Un-banded	Recap-tured	Adults	Young	Repr. Index[2]	Newly banded	Un-banded	Recap-tured	Adults	Young	Repr. Index[2]
Buff-banded Rail, *Gallirallus philippensis*		1						1				
Purple-caped Fruit-Dove, *Ptilinopus porphyraceus*	3			0.8	0.4	0.50	1			0.2	0.0	0.00
Many-colored Fruit Dove, *Ptilinopus perousii*	1			0.4	0.0	0.00						
Blue-crowned Lory, *Vini australis*							2	3		0.4	0.0	0.00
White-rumped Swiftlet, *Aerodramus spodiopygia*		1						3				
Collared Kingfisher, *Todiramphus chloris*	4		5	2.3	1.2	0.50	13		16	3.8	0.6	0.16
Samoan Shrikebill, *Clytorhynchus* [*vitiensis*] *powelli*							14		9	2.4	1.4	0.58
Wattled Honeyeater, *Foulehaio carunculata*	32		20	13.3	2.3	0.18	126	4	38	21.0	6.1	0.29
Samoan Starling, *Aplonis atrifusca*	7	1	1	1.2	1.9	1.67	68	5	10	8.3	4.8	0.58
Polynesian Starling, *Aplonis tabuensis*	5			1.2	0.8	0.67	5		1	1.2	0.0	0.00
ALL SPECIES POOLED	52	3	26	19.1	6.6	0.35	229	16	74	37.4	12.9	0.35
Total Number of Captures		81						319				
Number of Species	6	3	3	6	5		7	5	5	7	4	
Total Number of Species		8			6			9			7	

[2] Reproductive index (young/adult) is undefined because no adults of this species were captured at these stations in this year.

Table 4. Capture summary for the six individual TMAPS stations operated on the island of Tutuila, American Samoa (AMSA) during the 2015 season, November 2014 through March 2015. N = Newly banded, U = Unbanded, R = Recaptures of banded birds.

	Malaeloa			Malota			Mount Alava			Amalau			Tula			Vatia		
Species[1]	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Buff-banded Rail								1										
Purple-caped Fruit-Dove							2									1		
Many-colored Fruit Dove							1											
Blue-crowned Lory																		
White-rumped Swiftlet								1										
Collared Kingfisher			2	1		1	3		2									
Samoan Shrikebill																		
Wattled Honeyeater	2			12		6	14		7	1					2	3		5
Samoan Starling				5		1	1	1		1								
Polynesian Starling				2												3		
ALL SPECIES POOLED	2	0	2	20	0	8	21	3	9	2	0	0	0	0	2	7	0	5
Total Number of Captures		4			28			33			2			2			12	
Number of Species	1	0	1	4	0	3	5	3	2	2	0	0	0	0	1	3	0	1
Total Number of Species		2			4			7			2			1			3	

[1] Scientific names given in Table 3

Table 5. Capture summary for the six individual TMAPS stations operated on the island of Tau, American Samoa (AMSA) during the 2015 season, November 2014 through March 2015. N = Newly banded, U = Unbanded, R = Recaptures of banded birds.

	Luamaa			Laufuti Stream			Falaĉa			Usu Nua			Saunoa			Aokuso		
Species[1]	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Buff-banded Rail														1				
Purple-caped Fruit-Dove													1					
Many-colored Fruit Dove																		
Blue-crowned Lory											3					2		
White-rumped Swiftlet											3							
Collared Kingfisher	1		12	1			2			4			1			4		4
Samoan Shrikebill				2		5	10		4	1			1					
Wattled Honeyeater	24	1	9	16		5	12		3	36	2	6	18		7	20	1	8
Samoan Starling	10		3	1			1			18	3	2	7			31	2	5
Polynesian Starling										3			2		1			
ALL SPECIES POOLED	35	1	24	20	0	10	25	0	7	62	11	8	30	1	8	57	3	17
Total Number of Captures		60			30			32			81			39			77	
Number of Species	3	1	3	4	0	2	4	0	2	5	4	2	6	1	2	4	2	3
Total Number of Species		3			4			4			7			7			4	

[1] Scientific names given in Table 3.

Table 6. Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on the island of Tutuila, American Samoa (AMSA) during the 2015 season, November 2014 ï March 2015.

	Malaeloa			Malota			Mount Alava			Amalau			Tula			Vatia		
Species[1]	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.
Purple-caped Fruit-Dove							2.4	0.0	0.00							0.0	2.3	und.[2]
Many-colored Fruit Dove							1.2	0.0	0.00									
Blue-crowned Lory																		
Collared Kingfisher	6.5	0.0	0.00	1.8	1.8	1.00	3.7	2.4	0.67									
Samoan Shrikebill																		
Wattled Honeyeater	6.5	0.0	0.00	19.6	5.3	0.27	18.4	1.2	0.07	3.7	0.0	0.00	5.5	0.0	0.00	9.3	4.6	0.50
Samoan Starling				1.8	8.9	5.00	1.2	0.0	0.00	3.7	0.0	0.00						
Polynesian Starling				1.8	1.8	1.00										4.6	2.3	0.50
ALL SPECIES POOLED	13.0	0.0	0.00	24.9	17.8	0.71	26.9	3.7	0.14	7.5	0.0	0.00	5.5	0.0	0.00	13.9	9.3	0.67
Number of Species	2	0		4	4		5	2		2	0		1	0		2	3	
Total Number of Species		2			4			5			2			1			3	

[1] Scientific names given in Table 3.

[2] Reproductive index (young/adult) is undefined because no adults of this species were captured at this station in this year.

Table 7. Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on the island of Tau, American Samoa (AMSA) during the 2015 season, November 2014 – March 2015.

	Luamaa			Laufuti Stream			Falaʻa			Usu Nua			Saunoa			Aokuso		
Species[1]	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.	Ad.	Yg.	Rep. Ind.
Purple-caped Fruit-Dove													1.1	0.0	0.00			
Many-colored Fruit Dove																		
Blue-crowned Lory																2.2	0.0	0.00
Collared Kingfisher	8.1	0.0	0.00	1.7	0.0	0.00	3.3	0.0	0.00	2.1	2.1	1.00	1.1	0.0	0.00	5.4	1.1	0.20
Samoan Shrikebill				6.9	1.7	0.25	13.3	6.7	0.50	0.0	1.0	und.[2]	0.0	1.1	und.[2]			
Wattled Honeyeater	15.2	9.11	0.60	29.4	3.5	0.12	16.7	3.3	0.20	30.2	8.3	0.28	13.3	6.7	0.50	22.6	3.2	0.14
Samoan Starling	7.1	4.1	0.57	1.7	0.0	0.00	0.0	1.7	und.[2]	11.5	7.3	0.64	5.6	1.1	0.20	18.3	11.8	0.65
Polynesian Starling										3.1	0.0	0.00	3.3	0.0	0.00			
ALL SPECIES POOLED	30.4	13.2	0.43	39.8	5.2	0.13	33.3	11.7	0.35	46.9	18.8	0.40	24.4	8.9	0.36	48.4	16.1	0.33
Number of Species	3	2		4	2		3	3		4	4		5	3		4	3	
Total Number of Species		3			4			4			5			6			4	

[1] Scientific names given in Table 3.

[2] Reproductive index (young/adult) is undefined because no adults of this species were captured at this station in this year.

Table 8. Mean numbers of aged individual birds[1] captured per 600 net-hours and reproductive index for six MAPS stations pooled on each of the Islands of Tutuila and Ta'u, American Samoa (AMSA), from November - March averaged over the three seasons (2013, 2014, and 2015).

	Island of Tatuila[2]								Island of Ta'u					
	2013		2014		2015		Mean 2014/2015		2014		2015		Mean 2014/2015	
Species[1]	Adult/ 600 nh	RI	Adult/ 600 nh	RI	Adult/ 600 nh	RI	Adult/ 600 nh	RI	Adult/ 600 nh	RI	Adult/ 600 nh	RI	Adult/ 600 nh	RI
Purple-collared Fruit-Dove	1.86	0.00	1.35	0.13	0.78	0.50	1.07	0.31	0.93	0.00	0.20	0.00	0.56	0.00
Many-colored Fruit Dove	0.00		0.00		0.39	0.00	0.39	0.00						
Blue-crowned Lory									1.62	0.14	0.40	0.00	1.01	0.07
Collared Kingfisher	3.94	0.65	2.53	0.40	2.34	0.50	2.43	0.45	5.78	0.20	3.84	0.16	4.81	0.18
Samoan Shrikebill									3.93	0.41	2.42	0.58	3.19	0.50
Cardinal Honeyeater	0.46	0.00												
Wattled Honeyeater	14.15	0.25	8.60	0.28	13.25	0.18	10.93	0.23	38.17	0.07	21.00	0.29	29.59	0.18
Samoan Starling	2.09	0.78	1.52	0.33	1.17	1.67	1.35	1.00	11.57	0.14	8.28	0.58	9.92	0.36
Polynesian Starling	1.39	0.67	1.69	0.00	1.17	0.67	1.43	0.33	0.69	2.00	1.21	0.00	0.95	1.00
ALL SPECIES POOLED	23.90	0.36	15.69	0.27	19.09	0.35	17.48	0.31	62.70	0.14	37.35	0.35	50.03	0.25

[1] Only four stations were are included in 2013 values for the Island of Tatuila (Amalau, Malaeloa, NPAS - Mt. Alava, Malota).
[2] Only resident landbird species for which there was at least one aged individual of the species in either of the seasons are included in this table.

Table 9. Estimates of adult annual survival and recapture probabilities among newly captured adults using a time-constant, non-transient model for two species breeding at the four long term stations on the Island of Tutuila, American Samoa (AMSA), obtained from three years[1] of mark-recapture data.

Species[2]	No. stn.[3]	No. indv.[4]	No. capt.[5]	No. btwn-yr recp.[6]	Survival probability[7]			Recapture probability[8]		
					φ	SE(φ)	CV(φ)	p	SE(p)	CV(p)
Collared Kingfisher *À	4	27	38	7	0.754	0.449	59.5%	0.236	0.452	191.5%
Wattled Honeyeater *À	4	126	151	15	0.828	0.385	46.5%	0.108	0.074	68.5%

[1] Only data collected during the core breeding season (November-March) were included for the three seasons (2013-2015).

[2] Species included are those for which (a) an average of at least 2.5 individual adult birds were captured per year over the three years, 2013-2015, (b) at least two between-year recaptures were recorded during the three years from all stations pooled, and (c) survival and recapture probabilities were neither 1.000 nor 0.000.

[3] Number of stations at which at least one adult individual of the species was captured.

[4] Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).

[5] Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.

[6] Total number of between-year recaptures, a recapture in a given year of a bird originally banded at the same station in a previous year.

[7] Survival probability (ű) presented as the maximum likelihood estimate (standard error of the estimate). Defined as the probability of an adult bird surviving to and returning in a particular year (breeding season) to the area where it was present in the previous year (breeding season). The estimated probability (φ), standard error of the estimate (SE(φ)), and coefficient of variation (CV(φ)=100*SE(φ)/φ) are presented.

[8] Recapture probability (p) presented as the maximum likelihood estimate (standard error of the estimate). Defined as the conditional probability of recapturing an adult bird at least once in a particular year (breeding season), given that it did survive and return to the area where it was present in the previous year (breeding season). The estimated probability (p), standard error of the estimate (SE(p)), and coefficient of variation (CV(p)) are presented.

* The estimate for survival probability should be viewed with caution because it is based on fewer than five between-year recaptures or the estimate is very imprecise (SE(φ)Ó0.200 or CV(φ) Ó50.0%)

ÀThe estimate for survival probability, recapture probability, or both may be biased low because for Ű(proportion of residents) was set at 1.00.

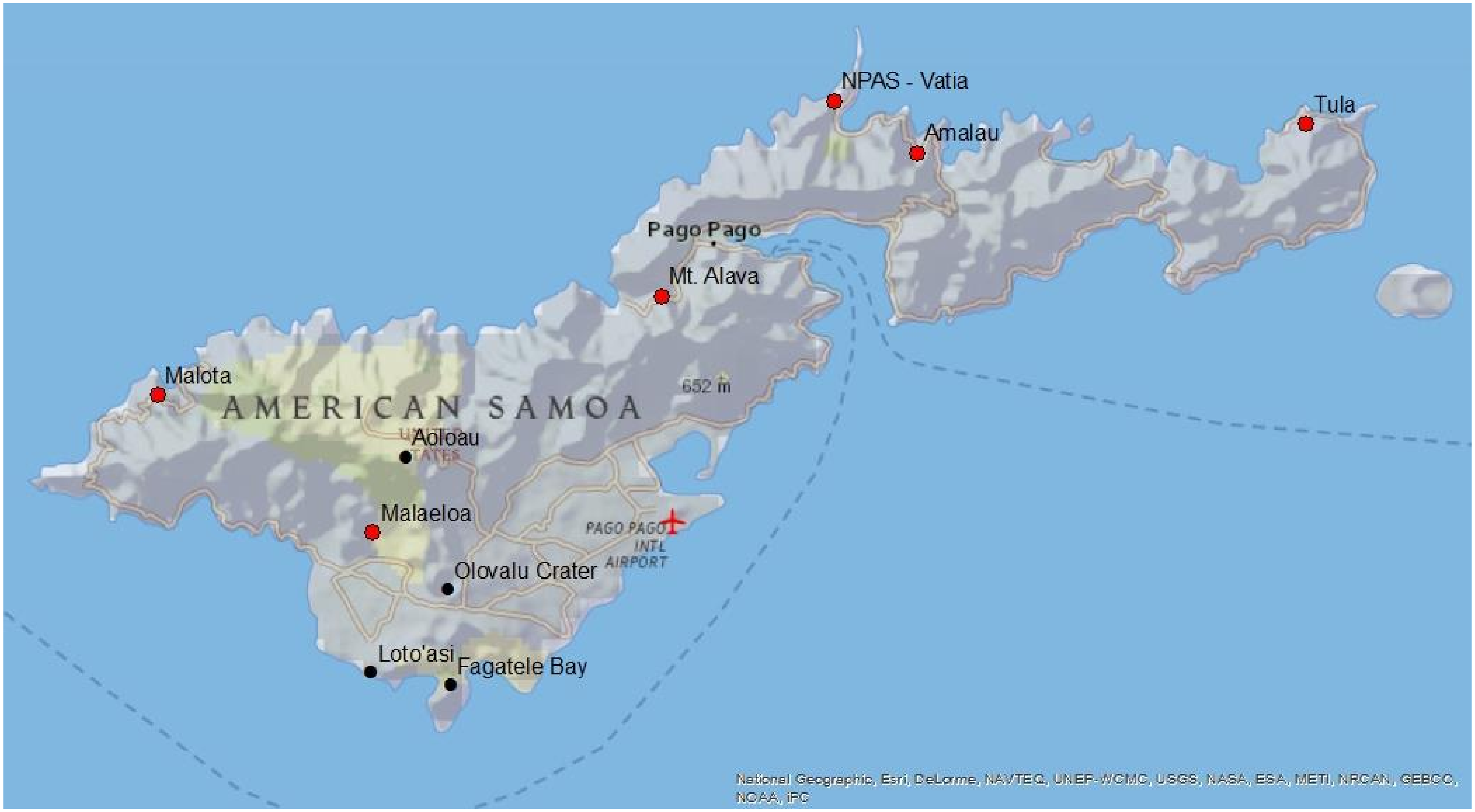

Figure 1. Locations of the ten Tropical Monitoring Avian Productivity and Survivorship (TMAPS) stations operated on Tutuila Island, American Samoa, in 2012-2015. Active stations are shown by red circles, non-active stations by black circles.

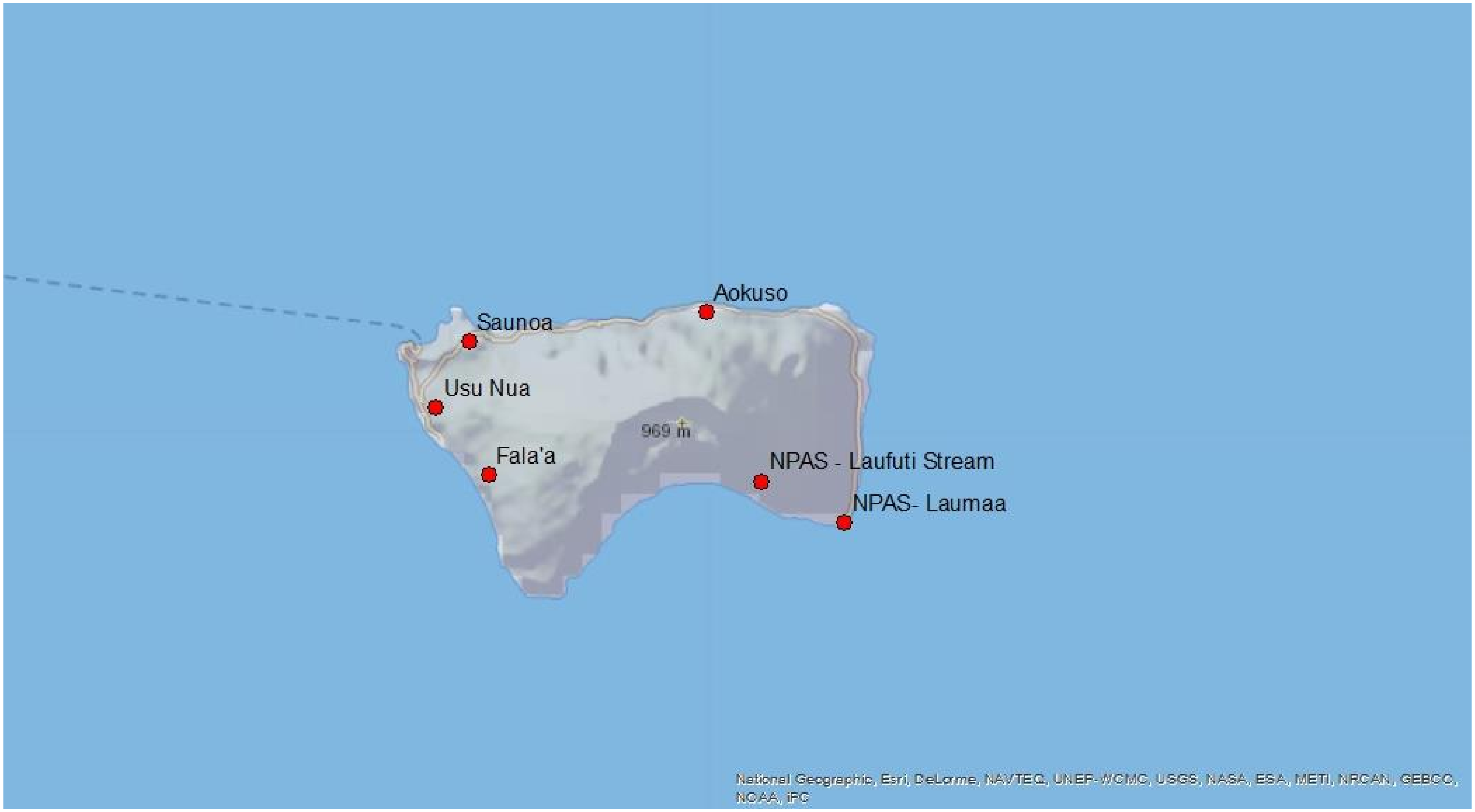

Figure 2. Locations of the six Tropical Monitoring Avian Productivity and Survivorship (TMAPS) stations operated on Tau island, American Samoa, during the 2014 and 2015 seasons.